

# STAT 514 Lecture 12

## Example

A rocket propellant manufacturer is studying the burning rate of propellant from three production processes. Four batches of propellant are randomly selected from the output of each process, and three determinations of burning rate are made on each batch. The results follow.

	Process 1				Process 2				Process 3			
Batch	1	2	3	4	1	2	3	4	1	2	3	4
	25	19	15	15	19	23	18	35	14	35	38	25
	30	28	17	16	17	24	21	27	15	21	54	29
	26	20	14	13	14	21	17	25	20	24	50	33

1. Explain why “batch” is nested under “process”.

**Solution:**

The reasons are: (i) “batch” has four levels at each level of “process”; (ii) under the same level of “process”, the levels of “batch” are comparable; (iii) under a level of “process”, the levels of “batch” can be arbitrarily numbered (i.e. the levels of “batch” from different levels of “process” are not comparable).

2. Analyze the data and draw conclusions.

**Solution:**

Process has fixed effects, and batch has random effects nested within process. From SAS output, we have:

```

Type 1 Analysis of Variance
Source          DF Sum of Squares   Mean Square   Expected Mean Square
proc            2  676.055556         338.027778  Var(Residual) + 3 Var(batch(proc)) + Q(proc)
batch(proc)     9  2077.583333         230.842593  Var(Residual) + 3 Var(batch(proc))
Residual       24  454.000000          18.916667  Var(Residual)

Error Term Error DF F Value Pr > F
MS(batch(proc))  9  1.46    0.2815
MS(Residual)    24 12.20   <.0001
.                .  .      .

Covariance Parameter Estimates
Cov Parm      Estimate
batch(proc)    70.6420
Residual       18.9167
    
```

We fail to reject the null hypothesis for process, but reject the null hypothesis for batch. Hence, our conclusion is: Processes are not different, but there is significant variability due to random batches.